ORGANIC EL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to an organic EL (Electroluminescent) display device.

2. Description of the Related Art:

For example, in an active-matrix-type organic EL display device, respective gate signal lines which extend in the x direction and are arranged in parallel in the y direction and respective drain signal lines which extend in the y direction and are arranged in parallel in the x direction are formed on one surface of a substrate and regions surrounded by the gate signal lines and the drain signal lines constitute pixel regions. Each pixel region is provided with a switching element which is turned on in response to a scanning signal from the gate signal line and a pixel electrode to which a video signal is supplied from the drain signal line through the switching element.

The pixel electrode is configured such that a light emitting material layer is interposed between the pixel electrode and a counter electrode and the light emitting material layer emits light due to an electric current which flows between the pixel electrode and the counter electrode. Here, the counter electrode is, for example, formed over respective pixel regions in common and a signal having a voltage which becomes the reference with respect to the video signal is applied to the counter electrode.

Then, by forming at least either one electrode out of the pixel electrode and the counter electrode using a light-transmitting conductive layer, light from the light emitting material layer can be taken out to this one electrode side and the light reaches eyes of an observer.

The aforementioned patent gazette the inventors of the present patent application referred is identified as follows.

Patent Document 1: Japanese Unexamined Patent Publication 1996-321381.

Patent Document 2: Japanese Unexamined Patent Publication 2000-223271.

SUMMARY OF THE INVENTION

However, with respect to the organic EL display device having such a constitution, it has been pointed out that the light emitting material layer is liable to be easily degraded by an ambient light from the sun or a fluorescent lamp.

This is because that polyphenylene vinylene (PPV) or the like, for example, contained in the light emitting material layer generates the photooxidation due to the radiation of the ambient light and is decomposed.

Accordingly, there has been a drawback that the lifetime and the stability of the organic EL display device cannot be sufficiently ensured.

The present invention has been made under such circumstances and it is an object of the present invention to provide an organic EL display device which can obviate the degradation of a light emitting material layer.

To briefly explain the summary of representative inventions among the inventions disclosed in this specification, they are as follows.

Means 1.

In an organic EL display device according to the present invention in which, for example, a light emitting material layer is formed on one surface side of a substrate and light from the light emitting material layer is taken out to the substrate side, the improvement is characterized in that a material layer capable of absorbing light having a wavelength of not less than 350nm and not greater than 410nm is formed on another surface side of the substrate.

Means 2.

In an organic EL display device according to the present invention in which, for example, a light emitting material layer is formed on one surface side of a substrate and

light from the light emitting material layer is taken out to the substrate side, the improvement is characterized in that a material layer capable of absorbing light having a wavelength of not less than 350nm and not greater than 410nm is formed between the light emitting material layer and the substrate.

Means 3.

The organic EL display device according to the present invention is, for example, formed based on the constitution of means 1 and is characterized in that a circularly polarizing plate is formed such that the circularly polarizing plate is stacked on another surface side of the substrate together with the material layer.

Means 4.

The organic EL display device according to the present invention is, for example, formed based on the constitution of means 3 and is characterized in that the circularly polarizing plate is fixed to the material layer by way of an adhesive agent and an ultra-violet-ray absorbing material is mixed into the adhesive agent.

Means 5.

The organic EL display device according to the present invention is, for example, formed based on the constitution of means 3 and is characterized in that the material layer also functions as an adhesive agent which fixes the circularly polarizing plate to the substrate.

Means 6.

In an organic EL display device according to the present invention in which, for example, a light emitting material layer is formed on one surface side of a substrate and light from the light emitting material layer is taken out to the substrate side, the improvement is characterized in that a touch panel is arranged on another surface side of the substrate and the touch panel is fixed to the substrate using an adhesive agent which absorbs light having a wavelength of not less than 350nm and not greater than 410nm.

One example of the organic EL display device according to the present invention can also be described concretely as follows.

In an organic EL display device which comprises a substrate having a first principal surface and a second principal surface opposed to the first principal surface and a light emitting material layer (formed of an organic electroluminescent material) formed at the first principal surface of the substrate, a material layer (a light absorption layer) absorbing light of a wavelength band lying between 350nm and 410nm is formed at the second principal surface of the substrate to be opposite to the light emitting material layer. If a plurality of the light emitting material layers are arranged two-dimensionally in the first principal surface of the substrate, the light absorption layer may be extended in the second principal surface so as to be opposite to the plurality of the light emitting material layers. If at least one organic material layer is provided at least one of an upper side and a lower side of the light emitting material layer formed above the first principal surface of the substrate, the light absorption layer should be formed to be opposite to the at least one organic material layer. Consequently, the light absorption layer shields the light emitting material layer (and the at least one organic material layer) from a component of external light incident on the second principal surface from the outside of the organic EL display device having a wavelength not less than 350nm and not greater than 410nm.

Here, the present invention is not limited to the above-mentioned constitutions and various modifications are conceivable without departing from the technical concept of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a constitutional view showing one embodiment of a pixel of an organic EL display device according to the present invention and is a cross-sectional view taken along a line I-I in Fig. 2;

Fig. 2 is a plan view showing one embodiment of the pixel of the organic EL display device according to the present invention;

Fig. 3 is a cross-sectional view showing another embodiment of the pixel of the organic EL display device according to the present invention;

Fig. 4 is a cross-sectional view showing another embodiment of the pixel of the organic EL display device according to the present invention;

Fig. 5 is a cross-sectional view showing another embodiment of the pixel of the organic EL display device according to the present invention; and

Fig. 6 is a cross-sectional view showing another embodiment of the pixel of the organic EL display device according to the present invention.

DETAILED DESCRIPTION

An embodiment of an organic EL display device according to the present invention is explained in conjunction with attached drawings.

Embodiment 1.

<<Constitution of pixel>>

Fig. 2 is a plan view showing one embodiment of a pixel of an organic EL display device. Further, a cross section taken along a line I-I in Fig. 2 is shown in Fig. 1.

Here, the pixel shown in Fig. 2 shows one of respective pixels which are arranged in a matrix array and hence, respective pixels which are arranged at left and right sides and above and below the pixel have the similar constitution.

In Fig. 2, for example, on a left-lower portion of each pixel region on a surface of a substrate SUB1 made of glass, for example, (see Fig. 1), a semiconductor layer PS which is formed of a polysilicon layer extending in the x direction in the drawing is formed. This semiconductor layer PS constitutes a semiconductor layer of a thin film transistor TFT.

Further, an insulation film GI (see Fig. 1) is formed on the surface of the substrate SUB1 such that the insulation film GI also covers the semiconductor layer PS. The insulation film GI functions as a gate insulation film on a region where the thin film transistor TFT is formed.

On a surface of the insulation film GI, gate signal lines GL which extend in the x direction and are arranged in parallel in the y direction are formed. The gate signal lines GL are formed such that the gate signal lines GL define the above-mentioned pixel region together with drain signal lines DL described later.

Further, the gate signal line GL is formed in common with respect to respective pixel regions arranged in parallel in the x direction in the drawing.

Further, the gate signal line GL has a portion thereof formed in an extending portion which extend such that the extending portion traverses an approximately center portion of the semiconductor layer PS and this extending portion functions as a gate electrode GT of the thin film transistor TFT.

Here, after formation of the gate electrode GT, impurity ions are implanted to the semiconductor layer PS using the gate electrode GT as a mask so that portions of the semiconductor layer PS at regions other than a region arranged immediately below the gate electrode GT exhibit low resistance.

An insulation film IN (see Fig. 1) is formed on the surface of the substrate SUB1 such that the insulation film IN also covers the gate signal lines GL (gate electrodes GT). The insulation film IN functions as an interlayer insulation film with respect to the gate signal lines GL in regions where the drain signal lines DL explained hereinafter are formed.

The drain signal lines DL which extend in the y direction and are arranged in parallel in the x direction are formed on a surface of the insulation film IN. A portion of the drain signal line DL extends to an end portion of the semiconductor layer PS and is connected with the semiconductor layer PS via through hole TH1 which is

preliminarily formed penetrating the insulation film IN and the insulation film GI. That is, the extending portion of the drain signal line DL functions as a drain electrode SD1 of the thin film transistor TFT.

Further, the drain signal line DL is formed in common with respect to respective pixel regions which are arranged in parallel in the y direction in the drawing.

Further, a source electrode SD2 is formed on another end portion of the semiconductor layer PS to be connected to the semiconductor layer PS via a through hole TH2 which is formed to pierce both the insulation film IN and the insulation film GI beforehand, and the source electrode SD2 has an extension portion thereof formed to be connected with the pixel electrode PX described later.

On the surface of the substrate SUB1 on which the drain signal lines DL (drain electrodes SD1) and the source electrodes SD2 are formed, an insulation film IL (see Fig. 1) is formed.

On an upper surface of the insulation film IL, the pixel (anode) electrode PX is formed at the center except for a trivial periphery of each pixel region, while the pixel electrode PX is connected to the source electrode SD2 of the thin film transistor TFT via a through hole TH3 formed in the insulation film IL. Here, the pixel electrode PX is formed of a light transmitting conductive film made of ITO (Indium Tin Oxide) or the like, for example. This provision is made for allowing light from the light emitting material layer FLR described later to transmit to the substrate SUB1 side.

On an upper surface of the pixel electrode PX, the light emitting material layer FLR is formed by way of a hole transporting layer HTP and an electron injection layer EPR is further stacked on the light emitting material layer FLR. These respective layers including the light emitting material layer FLR and the light emitting material layer and the like of another pixel region are formed such that they are defined by bank (partition wall) films BNK formed of an organic material layer.

On upper surfaces of the electron injection layer EPR and the bank film BNK, a counter (cathode) electrode CT which is common with respect to respective pixel regions is formed. A substrate SUB2 made of glass, for example, is laminated to an upper surface of the counter electrode CT by way of a high molecular resin seal PSL.

By allowing an electric current to flow in the light emitting material layer FLR interposed between the pixel electrode PX and the counter electrode CT, the light emitting material layer FLR emits light and this light LT can be observed with eyes through the pixel electrode PX and the substrate SUB1.

Here, a voltage signal which becomes the reference with respect to the video signal is applied to the counter electrode CT, while the video signal is applied to the pixel electrode PX from the drain signal line DL through the thin film transistor TFT. Further, the thin film transistor TFT is turned on in response to the scanning signal from the gate signal line GL.

Further, in this embodiment, on a surface of the substrate SUB1 which is opposite to the surface of the substrate SUB1 on which the light emitting material layer FLR is formed, that is, on an observation-side surface, first of all, a protective film PAS is formed.

The protective film PAS is formed of a material which absorbs light having a short wavelength of not less than 350nm and not greater than 410nm and hence, out of an ambient light from the substrate SUB1, the light having the above-mentioned wavelength is not irradiated to the light emitting material layer FLR.

As the protective film PAS, for example, UV GUARD (made by Fuji Photo Film Company Ltd., Tokyo, Japan) or an ultra violet ray cut filter/ clear-type (made by Ruru Inc., Osaka, Japan) can be selected.

That is, the protective film PAS is provided for preventing the decomposition generated by photooxidation of the light emitting material layer FLR due to the irradiation of light having the above-mentioned wavelength thus sufficiently ensuring the

lifetime and the stability of the light emitting material layer FLR.

Further, a circularly polarizing plate ORI is fixed to the protective film PAS by way of an adhesive agent AD. The circularly polarizing plate ORI is provided for overcoming difficulty of observing a display screen caused by the reflection of the ambient light on the counter electrode CT.

In this case, since the circularly polarizing plate ORI also has a function of blocking the light having a short wavelength, along with the function of the protective film PAS, the circularly polarizing plate ORI also has an advantageous effect to enhance the reliability with respect to the life time and the stability of the light emitting material layer FLR.

Further, it is possible to obtain the further reliable advantageous effect by using an adhesive agent containing an ultra-violet-ray absorbing material as the adhesive agent AD which is required for fixing the circularly polarizing plate ORI to the protective film PAS. Here, as the ultra violet ray absorbing material, for example, 2-(3-Cyano-3-methylsulfonyl-2-propenylidene)-3-(3-sulfobutyl)-thiazoline sodium salt which is obtained as a product number: ADA3193 of H.W. SANDS CORP. (FL., USA) or the like can be used. This ultra-violet-ray absorbing material, as described in Home Page: http://www.hwsands.com/snapshotpgs/ada3193snap.htm of H.W. SANDS CORP., favorably absorbs light of a wavelength band lying from 350nm as a longer wavelength side of an ultraviolet region to 410nm as a shorter wavelength side of a visible region (violet) with respect to 382nm as a center of the wavelength band where the maximum optical absorption value thereof appears. By mixing a proper amount of such a ultra-violet-ray absorbing material into an acrylic tacky adhesive agent, the above-mentioned adhesive agent can be obtained. In place of this ultra-violet-ray absorbing material, a benzotriazole series organic compound or a benzophenone series organic compound may be used. Further, the above-mentioned adhesive agent may be prepared by dispersing particulates of inorganic material such as zinc oxide, cerium

oxide, zirconium oxide, iron oxide, titanium oxide as a filler into a binder such as resin material which constitutes the tacky adhesive agent. Particularly, when zinc oxide is used as the filler of an adhesive layer, for the increase of a dispersion amount of the filler into the binder, it is possible to maintain the adhesive layer in a transparent state with respect to the visible light having a wavelength of not less than 410nm.

<<Manufacturing method>>

In the above-mentioned constitution, as the substrate SUB1, a substrate having a thickness of 1.1mm, for example, is used.

Further, as the pixel electrode PX, for example, an ITO (Indium Tin Oxide) film having a a thickness of 150nm, for example, is formed over an area of 150μm × 170μm by a selective etching method based on a photolithography technique.

An acrylic high molecular resin film having a film thickness of 1μm, for example, is applied as the bank film BNK and is formed by a selective etching method based on a photolithography technique. Here, after the formation of the bank film BNK, the substrate SUB1 having the bank film BNK is cleaned and is subjected to a UV ozone irradiation treatment so that a remaining organic component on a surface of the pixel electrode PX exposed from the bank film BNK is removed or cut off.

Next, using a vacuum evaporation shadow mask, the hole-transporting layer HTP is selectively formed on an upper surface of the pixel electrode PX surrounded by the bank film BNK. This hole-transporting layer HTP having a film thickness of 50nm, for example is formed of N,N'-di(1-naphthyl)-N,N'-diphenyl-{1,1'-biphenyl}-4,4'-diamine,αNPD, under 10^{-6} torr at a vacuum evaporation rate of 0.2nm/sec.

Further, using the above-mentioned vacuum evaporation shadow mask, the light emitting material layer FLR is formed on an upper surface of the hole-transporting layer HTP. This light emitting material layer FLR having a film thickness of 40nm, for example, is formed of tris(8-quinolinolato)aluminum complex, Alq, for example, under

the same conditions at the time of forming the above-mentioned hole-transporting layer HTP.

Under the same conditions, the electron injection layer EPR formed of LiF and having a film thickness of 0.5nm, for example, is formed. Thereafter, an aluminum layer having a thickness of 100nm, for example, is formed by vacuum evaporation at a vacuum evaporation rate of 1nm/sec, for example, thus forming the counter electrode CT made of the aluminum layer.

Then, the substrate SUB1 formed in this manner is transferred to a sealing glove box, wherein the substrate SUB2 made of glass, for example, is laminated to a surface of the substrate SUB1 on which the counter electrode CT is formed using the high molecular resin seal PSL of an ultraviolet curing type and, thereafter, the high molecular resin seal PSL is cured for sealing by the irradiation of ultraviolet rays.

Then, on a surface of the substrate SUB1 opposite to the surface on which the light emitting material layer FLR is formed, the protective film PAS is formed. The protective film PAS is made of a material which absorbs a short wavelength light up to 410nm.

Further, the circularly polarizing plate ORI is laminated to a surface of the protective film PAS by way of the adhesive agent AD.

<< Advantageous Effect>>

In the organic EL display device having such a constitution, between the pixel electrode PX and the counter electrode CT, a DC voltage is applied and the luminance-voltage characteristics of a green light emission from the light emitting material layer is measured and the luminance of approximately 1000cd/m^2 is obtained at a voltage of 8V. Thereafter, when a xenon lamp light is irradiated for 5 hours at an illumination of 6mW/cm^2 (wavelength: 405nm) and the luminance-voltage characteristics of the light emission is measured, the luminance of approximately 930cd/m^2 is obtained at a voltage of 8V.

Here, with respect to the above-mentioned organic EL display device having no such protective film PAS, when the xenon lamp light is irradiated for 5 hours at an illumination of $6mW/cm^2$ (wavelength: 405nm) and the luminance-voltage characteristics of the light emission is measured, the luminance of approximately $600cd/m^2$ is obtained at a voltage of 8V.

According to the present invention, in the organic EL display device which forms the light emitting material layer FLR on one surface (first main surface) of the substrate SUB1, the material layer (the protective film PAS, the adhesive layer AD) which absorbs the light having a wavelength band of not less than 350nm and not greater than 410nm is formed on another main surface of the substrate SUB1 (the second main surface which faces the first main surface in an opposed manner) such that the material layer faces the light emitting material layer FLR in an opposed manner. This material layer absorbs not only the ultraviolet rays but also the light of small-wavelength side of the visible region. Accordingly, when the light emitted from the light emitting material layer FLR is irradiated from another main surface (the second main surface) of the substrate SUB1 to the outside of the display device (the display panel), the visible light having a short-wavelength (the violet light) is also absorbed. However, when either one of the monochromic image or the color image is displayed using the organic EL display device, since the luminance and the tone are adjusted at the side having a wavelength longer than 410nm and hence, there is no possibility that the material layer degrades the quality of the display image. Rather, the material layer can absorb the light of the wavelength band containing a portion of the visible region which may be selectively absorbed in the light emitting material layer and the organic material layer arranged close to the light emitting material layer and can accelerate the decomposition of such layers, whereby the organic EL display device according to the present invention can maintain the sufficient light emitting luminance even after the excessive ambient light is irradiated.

Embodiment 2.

In the embodiment 1, in laminating the substrate SUB2 to the substrate SUB1 using the high molecular resin seal PSL, the constitution which fills the high molecular resin seal PSL in the inside of the region surrounded by the bank film BNK is adopted. However, it is needless to say that the region may be formed in a hollow shape.

Further, as the adhesive agent AD which adheres the circularly polarizing plate ORT to the protective film PAS, for example, a material which mixes 20% of the above-mentioned 2-(3-Cyano-3-methylsulfonyl-2-propenylidene)-3-(3-sulfobutyl)-thiazoline sodium salt which is obtained as a product number: ADA3193 of H.W. SANDS CORP. into the acrylic tacky adhesive agent may be used.

In the organic EL display device having such a constitution, between the pixel electrode PX and the counter electrode CT, a DC voltage is applied and the luminance-voltage characteristics of a green light emission from the light emitting material layer is measured and the luminance of approximately 1000cd/m^2 is obtained at a voltage of 8V. Thereafter, when a xenon lamp light is irradiated for 5 hours at an illumination of 6mW/cm^2 (wavelength: 405nm) and the luminance-voltage characteristics of the light emission is measured, the luminance of approximately 910cd/m^2 is obtained at a voltage of 8V.

Embodiment 3.

In the embodiment 1, in sequentially forming the hole-transporting layer HTP and the light emitting material layer FLR, for example, the vacuum evaporation shadow mask is used. However, it is needless to say that the hole-transporting layer HTP and the light emitting material layer FLR are sequentially formed using an ink jet method.

That is, 50pl of a PEDOT/PSS aqueous solution (poly(ethylenedioxy) thiophene/poly(styrene sulfonic acid) aqueous solution made by Bayer AG. Leverkusen, Germany) is ejected from a nozzle to form the hole injection layer HTP having a

thickness of approximately 50nm by the ink jet method and, thereafter, a polyfuluorene-based high molecular light emitting material (made by Dow Chemical Inc.) is ejected to form the light emitting material layer FLR having a thickness of 40nm by an ink jet method.

In the organic EL display device having such a constitution, between the pixel electrode PX and the counter electrode CT, a DC voltage is applied and the luminance-voltage characteristics of a green light emission from the light emitting material layer is measured and the luminance of approximately $1000cd/m^2$ is obtained at a voltage of 5.5V. Thereafter, when a xenon lamp light is irradiated for 5 hours at an illumination of $6mW/cm^2$ (wavelength: 405nm) and the luminance-voltage characteristics of the light emission is measured, the luminance of approximately $910cd/m^2$ is obtained at a voltage of 5.5V.

Here, with respect to the constitution of the above-mentioned organic EL display device having no such protective film PAS, when the xenon lamp light is irradiated for 5 hours at an illumination of $6mW/cm^2$ (wavelength: 405nm) and the luminance-voltage characteristics of the light emission is measured, the luminance of approximately $490cd/m^2$ is obtained at a voltage of 5.5V.

Embodiment 4.

Fig. 3 is a constitutional view showing another embodiment of the organic EL display device according to the present invention and corresponds to Fig. 1.

The organic EL display device shown in Fig. 1 is formed such that the protective film PAS is particularly formed on the surface of the substrate SUB1. It is needless to say that the adhesive agent AD which is used for adhering the circularly polarizing plate to the surface of the substrate SUB1 may be also used for performing the function of the protective film PAS.

That is, a material which absorbs light having a wavelength of not greater than 410nm may be mixed into the adhesive agent or the material is used as a material of the

adhesive agent per se.

Embodiment 5.

Fig. 4 is a constitutional view showing another embodiment of the organic EL display device according to the present invention and corresponds to Fig. 1.

The constitution which makes this embodiment different from the embodiment shown in Fig. 1 lies in that a so-called touch panel TP is arranged on the surface of the substrate SUB1 of the organic EL display device, wherein the touch panel TP is laminated to the circularly polarizing plate ORI which is formed on the surface of the substrate SUB1 by way of an adhesive agent AD.

Here, it is needless to say that a material which absorbs light having a wavelength of not less than 350nm and not greater than 410nm may be mixed into the adhesive agent AD or the material is used as a material of the adhesive agent AD per se.

Embodiment 6.

Fig. 5 is a constitutional view showing another embodiment of the organic EL display device according to the present invention and corresponds to Fig. 1.

The constitution which makes this embodiment different from the embodiment shown in Fig. 1 lies in that the protective film PAS which is formed on the observation side surface of the substrate SUB1 is formed on the surface of the substrate SUB1 at the light emitting material layer FLR side.

For example, the protective film PAS is formed as a background layer of the pixel electrode PX. However, the protective film PAS is not limited to such a constitution. That is, the protective film PAS may be formed such that at least one of several insulation films IN, IL and the like which are formed between the light emitting material layer FLR and the surface of the substrate SUB1 is provided with a function similar to the function of the protective film PAS.

Embodiment 7.

Fig. 6 is a constitutional view showing another embodiment of the organic EL display device according to the present invention and corresponds to Fig. 1.

The constitution which makes this embodiment different from the embodiment shown in Fig. 1 lies in, first of all, that the observation-side surface is formed at the substrate SUB2 side. Accordingly, at least the counter electrode CT is formed of a light transmitting conductive layer. In this case, the pixel electrode PX may be formed of a non-light-transmitting conductive film. Further, the substrate SUB2 is indispensably formed of a light transmitting material such as glass.

In this case, the protective film PAS is formed on the observation side surface of the substrate SUB2. In this embodiment, the protective film PAS, the adhesive agent AD and the circularly polarizing plate ORI are formed by sequentially stacking them from the observation-side surface of the substrate SUB2.

In such a constitution, it is needless to say that the modes described in conjunction with the above-mentioned respective embodiments (the constitution which forms the protective film PAS at the substrate SUB1 side) are directly applied to the observation-side surface of the substrate SUB2.

The above-mentioned respective embodiments may be used in a single form or in combination. This is because that the advantageous effects of respective embodiments can be achieved in a single form or synergistically.

As can be clearly understood from the foregoing explanation, according to the organic EL display device of the present invention, the degradation of the light emitting material layer can be obviated.